7th Symposium on Frequency Standards and Metrology

(Summary Submission for Oral Presentation)

Solutions and ultimate limits in temperature compensation of cylindrical microwave metallic resonators

Andrea De Marchi, Politecnico di Torino
andrea.demarchi@polito.it

The key problem for the use of metal cavities as the reference in Ultra Stable Oscillators (USO), for which they are otherwise attractive because of the high power level they can handle, is the high temperature sensitivity of the metals themselves. In fact many metals, especially when suitably treated, can be immune to long term creep and relaxation effects and therefore otherwise extremely stable dimensionally.

Various temperature compensation techniques have been proposed in the past for different resonators, but the only one that appears promising for a cylindrical high-Q TE_{0nm} resonator is the simple two-metal technique proposed in [1], which produces a parabolic minimum in the frequency to temperature curve and thus in principle the possibility of realizing a vanishing temperature coefficient at the operating point. However, crippling problems arise in this solution from the exceedingly high uncertainty with which the Coefficients of Thermal Expansion (CTE) of the two metals are known, and from their non linearity with temperature, which is even less well documented in the literature. The first problem makes it impossible to even design an improvement of much more than an order of magnitude in resonator temp-co without resorting to preemptive accurate measurements of the CTEs or profusion of time and efforts in trial and error procedures. The second problem, if not considered, can produce a second order term for the temp-co which is much bigger than expected from the analysis reported in [1] and impose unlikely machining accuracies in the realization of the metal parts. The result is that a resonance frequency temp-co much below 10 Hz/K at 10 GHz (or 10^-9/K) appears very hard to obtain with this approach.

In this contribution both problems are addressed and a novel approach is proposed following which they can be separately addressed, opening the way for further improvement of the resonance frequency temp-co into the 10^-10/K and possibly the 10^-11/K region. A 10 GHz cylindrical TE_{0nm} cavity is being realized with the new design criteria and first cut quick-and-dirty results will hopefully be available at the time of the Symposium.